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Making Explicit And Reinforcing Horizontal Competences In An Electronic Engineering Degree

Joaquín Portilla, Amparo Varona, Nerea Otegi

Department of Electricity and Electronics. Faculty of Science and Technology. University of the Basque Country - UPV/EHU, Barrio Sarriena s/n, Leioa 48940, Spain

Abstract

In the European higher education landscape, Dublin descriptors indicate that qualifications are awarded to students who have demonstrated knowledge and understanding in a field and can apply it in a "professional" way. In this context, "professionalism" must be interpreted as getting along in a working scenario context and this implies to manage some horizontal or generic skills. The subjects taking part of the program of a given degree focus on achieving knowledge in a given discipline. The day-to-day work in each subject is fundamentally oriented to get such knowledge, but, simultaneously, diverse horizontal competences or skills are implicitly acquired on the way. Graduate programs have to organize the activities building evidence of the achievement in acquiring such skills and competences. This adds value to the education process and helps to highlight the academic qualification. The implication is organizing the educational activity that allows developing competent persons. In this paper, we describe the horizontal competences in the Electronic Engineering degree, at the University of the Basque Country (UPV/EHU), and we deal with an analysis of the current situation and the development of a working-plan. The aim is to make explicit the work on horizontal skills that is already done in an implicit way and to propose actions to better coordinate and fill the gaps in the process. A simple and illustrative example to make explicit this work by means of a typical activity is provided.

Keywords: Horizontal Competences, Electronic Engineering, Skill Development, Learning Outcomes, Indicators;

1. Introduction

European higher education landscape is being built on the grounds of the Lisbon and Bologna Processes for education (Keeling, 2006). The leitmotifs of the new educational scenario are "lifelong learning" and "knowledge society".

Corresponding Author: Joaquín Portilla
E-mail: Portilla@gmail.com

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This European vision implies an educational challenge on education standardization and some canonical key-concepts such as "making new knowledge" and "building new competences and skills", these consisting of a mixture of professional and social, or horizontal, competences. Dublin descriptors indicate that qualifications are awarded to students who have demonstrated knowledge and understanding in a field and can apply it in a "professional" way (European Commission, Education and Training web page).

The Electronic Engineering (EE) degree at the University of the Basque Country (UPV/EHU), which is our matter of interest, has the willingness of maintaining a proper balance that favors a strong interaction between science and technology and this is one reason why it is taught in the Faculty of Science and Technology (ZTF-FCT). With the introduction of new curricula, in the academic year 2010/2011, at the UPV/EHU, an educational project was introduced to try to drive a cooperative and dynamic teaching-learning model (Cope, 2005), (Slavin, 1988) named IKD (from Basque *Ikaskuntza Kooperatibo eta Dinamikoa*, i.e. Cooperative and Dynamic Learning). In that context, we were firstly involved, during the academic year 2010/2011, in the preparation of an implementation plan for the development of horizontal competences of the EE degree at the ZTF-FCT of the UPV/EHU. For that, a synthetic formulation for the horizontal competences in the EE degree was undertaken (Portilla, Varona, & Otegi, 2012), with the aim of making easier the follow-up of that process.

On the other hand, EE is one of the nine degrees offered to students in the ZTF-FCT. A relatively significant number of subjects are shared among the different degrees. The fact was that curricula of each degree were independently developed on the basis of the different white papers for each scientific/technological discipline. As a practical consequence, the definition of horizontal competences was conducted in parallel during the development of curricula, so no homogenized formulations were finally settled. The next obvious task has been to standardize, as a next step in a process aimed to be coordinated to the fullest extent, the horizontal competences definition among the different degrees in the ZTF-FCT, trying to reformulate them in terms of some skills emphasizing aspects such as "learning to learn" or "cooperative work", for instance (Hoogveld, Pass, & Jochems, 2005). In this sense, the ZTF-FCT is working towards a coherent definition of horizontal competences, compatible among the different degrees. The analysis and reformulation of competences is being carried out by a team, consisting on representatives of the different degrees involved, and leaded and supervised by the Faculty direction. Different aspects are being considered: (1) Overall objectives of the degree; (2) Proficiency levels per academic year; (3) Methodology and (4) Evaluation.

In that context, we have, in particular, been working in the definition of learning outcomes and the indicators of proposed competences for the whole EE degree. Besides, we have made an analysis of the current situation and we have developed a working-plan for the degree. The aim is to make explicit the work on horizontal skills that is already done in an implicit way and to propose actions to better coordinate and fill the gaps in the process.

The paper contents are organized as follows. In section 2, we deal with the EE degree at UPV/EHU. Section 3 is devoted to the synthetic formulation of horizontal skills and associated learning outcomes in the UPV/EHU EE degree. Having the aim of making explicit the work on horizontal competences and filling the gaps, an analysis of the current situation has been undertaken. Details are provided in section 4. Planning and implementation issues are discussed in section 5. A simple example of explicit implementation of horizontal skills working on a typical activity is also presented. Finally, section 6 concludes the paper.

2. **The degree: Electronic Engineering**

EE is a universally recognized qualification, which historically emerges and thrives on the physical sciences and mathematics. Since its inception, the interest of electronics engineers and scientists focused on the technological development of components and circuits, based on the experimental sciences. Gradually, the activity was extended to areas more or less mature in instrumentation and control techniques, data acquisition, data storage, data processing and communication, reaching the design of all types of systems. In parallel, continuous advances, incremental and revolutionary, have been experienced along these years in the field of materials and solid-state devices that support those applications. Thus, the EE is a discipline that provides simultaneous coverage at various levels, from the scientific and technological developments related to materials and circuits, to more abstract, mathematical and functional, including those in the field of applications. This duality makes the EE is particularly gifted as an engine of technological development and innovation.

The Degree in EE at the UPV/EHU has the willingness of maintaining a proper balance that favors a strong interaction between science and technology and this is one reason that why is taught in the ZTF-FCT. In the

UPV/EHU, the degree in EE brings a background in physics and mathematics, incorporating knowledge of electronics as applied science from that base, which contributes to a better training to understand and follow the continuous evolution of electronic technologies and participate in innovation activities. EE will remain the place where technologies meet rigorous analysis and modelling skills that, in turn, leads to new insights on how to better engineering systems to support new and existing applications (Stanford University, "A Strategic Plan for Electrical…", 2006). While physics and mathematics have been typically the dominant suppliers of knowledge for previous generations of innovation, it can be expected that biology and chemistry will also provide increasingly important underlying science and technology in the future and is another important reason to offer the EE degree in the ZTF-FCT.

Finally, the EE degree of the UPV/EHU offers the possibility of obtaining a double degree by interaction with the Degree in Physics. The 4th academic year offers three possible specialization modules, one of which acts in fact as a technological/scientific gateway which allows the students obtaining the degree in physics in an additional academic year.

3. Horizontal skills and associated learning outcomes in the UPV/EHU Electronic Engineering degree

In the EE degree workbook, 13 specific or knowledge-related competences and 8 generic or horizontal competences were identified (Electronic Engineering Degree Workbook, UPV/EHU). Thereafter, there was a need of reformulating the generic competences, with the aim of obtaining a synthetic formulation with well-defined objectives to help the planning of activities and coordination tasks at several levels (in subjects shared by degrees, along different academic years of the degree, etc.) (Portilla, Varona, & Otegi, 2012).

The analysis and reformulation of competences was carried out taking into account the overall objectives of the degree, proficiency levels per academic year, as well as implementation aspects such as methodology and evaluation process. Four horizontal competences were finally proposed that can be expressed as:

- C1 (Knowledge management) Proficient use of the knowledge: documentation, critical analysis, skills for design simulations, experiments and prototypes.
- C2 (Working methodologies) Having skills in planning and organization and applying appropriate methodologies both in groups or/and individually: teamwork, planning and organization of task and projects, problem solving, proposal and project management.
- C3 (Communication skills) Communicating well orally and in writing
- C4 (Attitude at work) Showing a resolute, proactive and creative attitude, being compliant with ethical issues and responsibility.

We would like to highlight that the overall objectives of reformulated horizontal competences, C1 to C4, include all those skills that were described in the original EE curriculum document but using a different definition. In addition, we have to mention that these competences are totally coherent and compatible with the results of the standardization among different degrees being carried out by the Faculty working group.

4. Analysis of the current situation

The final objective is organizing the education in such a way that helps the student to simultaneously acquire specific knowledge and generic skills in order that they become competent persons. In this context we decided to make a survey among the docents involved in the different subjects in our EE degree. The goal of this survey was getting information to analyze the implicit work related to horizontal competences that is already done all along the degree. Moreover, the fact of making this survey is also useful to get the people informed and involved from the beginning in the process of developing work on horizontal competences. The questions were formulated by taking as reference the different kinds of activities undertaken in the subjects, instead of directly asking by the competences themselves. The point is that the work on such competences is implicitly developed through the different activities. Seven classes of activities were identified: Problem resolution, elaboration of written reports, oral expression (talks and debate), bibliographic studies and information analysis and synthesis, analysis and simulation exercises, experimental work and, finally, other possible activities such as virtual learning, visits to external laboratories or companies, etc. We asked to indicate if the activities are worked or not, if they are worked individually, with a partner or in-group, and finally, we propose one indicator of the level of development for each activity. Three levels

were proposed. The most basic one corresponds to providing a guideline to the students in order that they developed the activity. At this level the student produces some piece of work, the final result of which is globally evaluated. There is no feedback during the process. The second level involves providing the starting guidelines, but also a follow-up with feedback during the activity. Finally, the third level includes the follow-up and an explicit evaluation and feedback of the different aspects concerned in the development of the activity. The answers to the survey are summarized in Table 1.

The outcomes from the survey were then analyzed with the focus on the horizontal skills. In which concerns the competence C1, related to knowledge management, the main outcome of the survey is that learning of scientific and technical knowledge is well covered through different activities but, simultaneously, the actions concerning bibliographic studies and analysis and synthesis of information can be reinforced. Following with competence C2 (working methodologies), the main outcome is that methodological aspects are quite well covered but there is space for emphasizing teamwork. Results concerning competence C3 (communication skills) indicate that improvements have to be done in teaching formal aspects in written reporting, as well as in oral expression and, finally, understanding and communication in English language. Finally, competence C4 (attitude at work) can be improved by intensifying the work on best practices, open problems and project-oriented methodologies, and ethical analysis, for instance.

Subject	1 Problem solving	2 Reporting	3 Oral exposition and debate	4 Bibliography and information management	5 Practice sessions with analysis and simulation tools	6 Experimental work	7 Others (indicate)
Physic fundamentals	i						i (ICTs moodle)
Linear algebra and geometry	ig		i				i (ICTs moodle)
Differential and Integral Calculus	i				i		g (formal aspects)
Chemistry							i (ICTs moodle)
Computing basics	i	g	i			g	ig (ICTs moodle)
Experimental techniques I	i	p				p	
Programming fundamentals	i	p	i		ip		
Vector and complex analysis							
Mathematical methods							i (ICTs moodle)
Mechanics and waves							
Electromagnetism I							
Electronics	i				pg	pg	i (ICTs moodle)
Experimental techniques II	i	i				p	
Modern physics							
Digital electronics	i	ip	ig	g		ig	i (ICTs moodle)
Electronic and optoelectronic devices	i	i					i (ICTs moodle)
Signals and systems	i	p	i		p		
Modern programming techniques	i				i	ig	i (ICTs moodle)
Electromagnetism II	i						i (ICTs moodle)
Analog electronics	i	i	i		ip	p	i (ICTs moodle)
Linear and nonlinear circuits	ig	i	i		i		
Automatic control I	i	ig			ig	g	
Computer architecture	i					i	
Instrumentation I	i	ip	p	p	p	p	i (ICTs moodle)
Projects and enterprises fundamentals	i	i	ig	g		g	
Final graduate project		i	i	i			
Sensors and actuators	ig	p				p	g (workshop)
Instrumentation II		ig				g	i (ICTs moodle)
Automatic control II	-	-	-	-	-	-	-
Power electronics	ip		i		i		
Operating systems and real time techniques	-	-	-	-	-	-	-
Design of digital systems	i	i	i	i	p	p	i (ICTs moodle)
High frequency systems	i	p	g		p	p	i (ICTs moodle)
Microelectronics and microsystems	i		i				g (workshop)
Data and network communication	i				g	g	g (Company visit)
Communication electronics	i	p				p	i (ICTs moodle)
Quantum physics							
Thermodinamics and statistical physics	i		i				i
Optics							

Level indicator:
a. Guidelines are provided to the student to undertake the activity
b. Guidelines, follow-up and feedback
c. Guidelines, follow-up, feedback and detailed evaluation by item

Working modality:
i: individual or autonomous work
p: with a partner
g: team work

Table 1. Survey: Activities working horizontal skills by subject in EE Degree (UPV/EHU).

5. Planning and Implementation

Once the final goals have been settled and some activities to improve performance have been identified, the work has been focused on planning intermediate goals and programming activities in the pull of subjects, all along the degree. Follow-up and evaluation is achieved thanks to descriptors and progress indicators defined for each activity. The idea is that the students build their own portfolio (Barnett, 1995) from partial results and evidences in order to take perspective of their overall performance. An academic tutor is assigned to each student, to provide him or her assessment in the fulfilment of the goals.

Let us analyze an example that serves to illustrate a basic approach to explicitly treating the horizontal competences in a typical activity of the degree. For that, a very simple activity such as problem solving, carried out

in this case in the subject Electronics of second year, but common to almost every subject in the degree, is shown. In this activity the four horizontal competences defined are worked to their first domain level. The assessment-matrixes (Eduteka web page), (Andrade, 2000) shown in Tables 2A and 2B are a specification of the more general description (Portilla, Varona, & Otegi, 2012) developed as guideline for the learning outcomes associated to the first domain level.

Activity: Problem solving
Subject: Electronics
Academic year: 2nd

Objective: Circuit solving by using three methods (network analysis, Tableau and MNA).

Type: individual
Calendar: 3rd topic

Description:

Step 1: Each student receives a different circuit for solving it.
Step 2: Each student hands the resolution to the teacher.
Step 3: The teacher returns the corrections, emphasizing also in methodology, notation, written expression, etc.

C1 (Knowledge management)		
Domain level	Indicators	Descriptors
Gathering basic information and applying it in well-defined and limited Contexts	Gathering basic information	- Does not distinguish the three methods for solving the problem.
	Applying the information in well-defined limited contexts	- Shows basic notions on the three methods. - Distinguishes perfectly and knows how to apply the three methods.
C2 (Working methodologies)		
Domain level	Indicators	Descriptors
Systematic approach and analysis of basic problems, individually or in small groups, and deadline compliance	Systematic approach and analysis of basic problems	- There is no problem analysis - Partial analysis or inconsistence (lacks of variable definition, incoherence with the definition…) - Clear analysis and rigorous consistency (variables, system of equations…)
	Deadline compliance	- Has not fulfilled the deadline. - Has complied with the deadline.

Table 2A. Assessment-matrix of horizontal competences C1 and C2 at their first domain level for the proposed activity.

C3 (Communication skills)		
Domain level	Indicators	Descriptors
To take part and express oneself in a structured and intelligible way	Express oneself in a structured and intelligible way	- The work has not logical structure. - The structure of the work can be followed with difficulty. - The work is totally structured and intelligible.

	Using terminology of the area	- Does not know the basic terminology. - Partially knows and uses the basic terminology. - Dominates the basic terminology.
C4 (Attitude at work)		
Domain level	Indicators	Descriptors
To pay attention and to show respectful mood	To pay attention and Interest	- Does not show any interest (indications, correction…). - Shows limited interest. - Takes care of every step of the activity.
	Respectful mood	- Shows little respect (when receiving indications, at correction and feedback etc.). - Shows always respectful attitude.
	Ethical behaviour	- Shows unethical behaviour (presents copied work for instance). - Respects deontological codes.

Table 2B. Assessment-matrix of horizontal competences C3 and C4 at their first domain level for the proposed activity.

6. Final discussion

The subjects taking part of a graduate program mainly focus on getting knowledge in a given discipline. The day-to-day work in each subject is fundamentally oriented to get such knowledge, but, simultaneously, diverse horizontal competences or skills are implicitly acquired on the way. Graduate programs have to organize the activities building evidence of the achievement in acquiring such skills and competences. This adds value to the education process and helps to highlight the academic qualification. The implication is organizing the educational activity that allows developing competent persons.

In this paper we have introduced the Electronic Engineering degree at UPV/EHU, which is our matter of interest. We have proposed a synthetic formulation of horizontal skills and associated learning outcomes for the UPV/EHU EE degree. Having the aim of making explicit the work on horizontal competences and filling the existing gaps, an analysis of the actual situation has been undertaken and main conclusions have been addressed. Planning and implementation issues have been discussed and examples have been provided.

As a generic remark aiming to improve the results on the procedures adopted to make explicit and develop horizontal competences, we have to consider the reluctance to change (action and reaction) and the communication strategy. Note that issues mentioned are a commonality when dealing with changes in any organization and, precisely, makes themselves appeal to horizontal skills. European higher education is facing challenges that concern standardization and mission of education. The point is that there is somewhat a perception of a devaluation of acquired experience. The educational community misunderstands some changes and perceives them as impositions more than a result of debate and consensus. This ends in a lack of conviction in implementing changes. People need to understand what is changing and why. It is also important to understand their reluctance to change and program the changes as incremental and not as a rupture with what was usually done. In the academic world, getting people aligned by conviction rather than by imposition works much better.

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